can do so with very considerable accuracy. This leads me to the second experiment. (*b*) Let the observer, still with eyes closed and bandaged, stand up and be at liberty to move his head. Let the assistant produce the clicking sound, not once only, but again and again at short intervals, always in the same place. The observer turns round until he faces the source of sound. He knows that he is facing it when he hears it equally loud in both ears, and hears it to the right when he turns a little to the left, and to the left when he turns a little to the right, that is the criterion of whether the source is behind or before him. Having now got the azimuth, he seeks the altitude. Moving his head about a right and left axis, he seeks the position in which he hears the sound best. He is now looking towards the source of the sound.

The concha of the external ear acts as a screen, and it is remarkable how much difference there is in the quality as well as in the loudness of most sounds with different altitudes.

Stand in front of a pipe from which water is rushing, and move the head round a right and left axis, bow, in fact, to the pipe, and a striking difference in the quality and loudness of the sound will be observed in the different positions of the head.

It may be said birds have no concha, and yet they perceive as well as we do the direction of sound. But there is a method by which, without any use of the action of the concha, and by purely binaural observations, we can ascertain the direction of sound. By one observation, as already described, we can find a plane containing the line along which the sound reaches us. That plane is at right angles to the line joining our two ears. By moving the head we can shift the line joining our two ears, and then by another similar observation obtain the plane at right angles to the new position of the line joining the two ears and containing the direction of sound. The direction of sound is the intersection of these two planes.

I do not think *we* use this method (although I have tried it and found it work), but we often see birds incline their heads when listening in such a way as to suggest that they use it.

There is another objection which is often brought against the theory I have been explaining. It is said, "Is it conceivable that there should be a special sense, common to man and all vertebrate animals, which has remained unknown till about twenty-two years ago? This is a sense invented, not discovered by scientific men, otherwise we should all have known about its existence at least."

This objection is not one to be met by contempt; it has a real basis, and as I believe this sense to be a real one, I feel bound to look for the cause of the incredulity.

A special sense is popularly understood to be a gateway of knowledge. Information as to external things comes to us in various ways, and each of these ways has from ancient time been recognised and named as a special sense. But this is not exactly the physiological way of looking at things. I may illustrate the difference by a sort of analogy. In a large business establishment the manager sits in his room upstairs. He has various ways of getting information. The post brings him letters, he looks at them; some he carefully considers and answers, others he looks at and puts into the waste-paper basket—but he has looked at them all. So we *see* things; many of the things we consider, take note of, others we pay no attention to—do not an hour later remember anything about them. But there are many messages which come to the business establishment and never reach the manager's room at all. They are attended to by clerks in the office. They are not futile, they are real messages and serve their purpose, a purpose essential to the carrying on of the business. If these were not attended to downstairs, the manager would very soon hear of it. So with us. There are what we may call sensory impressions which do not make their way to the conscious *Ego*, but are all the same properly attended to by what in us corresponds to the clerks. If our clerks neglect their work, the conscious *Ego* very soon becomes aware that there is something wrong.

In the case of the sense of rotation, ordinarily we pay no attention to its messages—the clerks at the sensory centres of the ampullary nerves, and at the motor centres of the muscles of the eyeballs, do all that is necessary. We perceive the result of their work in our visual sense of the fixedness of the outside world, and we do not trouble ourselves as to how the office work has been done.

But—and here I come to a matter I referred to early in this lecture—the office work is sometimes not well done, and the visual sense of the fixedness of the outside world is lost. If this is due to disease, we send for the doctor and ask him to find out what is wrong in the office, and, if he can, put it right. But there is a far more common cause of the loss of the visual sense of the fixedness of the outside world, one which it has not been left for two or three scientific men to discover in the last quarter of the nineteenth century. The most characteristic effect of alcohol is to make all reflex actions sluggish. Under the influence of a moderate dose of alcohol, what I have called the office work, goes on all right but not quite so fast as with no alcohol. The message arrives, and the answer is sent, but not quite so promptly. The conscious *Ego* may not note anything wrong, but a quantity of alcohol, far short of a dangerously poisonous dose, may delay the transmission of the signal to the muscles of the eyeball so much as to affect quite perceptibly the compensation of the movements of the head. A perfectly sober man sees the world wag a little when he wags his head very vigorously—a point of light is perceptibly drawn out into a horizontal line of light—the office work fails a little under such extreme pressure. But a little alcohol makes the office work fail more readily, and as the dose is increased it fails altogether, and the sense of the fixedness of the world is wholly lost. Even in such an extreme case of intoxication, short of paralysis, the drunken man may see the world steady, if only he can keep himself steady. I dare say we have all seen very drunken men walking quite straight, but with a preternatural fixedness of the head. If anything makes them move their head, they totter and reel. They move the head a little; that happens to them in consequence of a small and slow rotation of the head, which happens to us when we wag our head violently, and they reel and stagger just as we should reel and stagger if we tried to walk, violently wagging our head all the time.

Just as there are blind men and deaf men, so there are men who have lost or never had the sense of rotation. Such persons are almost always deaf-mutes. The close anatomical relation of the organ of hearing and the organ of the sense of rotation has this effect, that imperfect development of pathological injury of the one is usually associated with similar defect in the other. And experiments on deaf-mutes have shown that a large proportion of them are defective in the sense of rotation. This is shown by the absence of the normal jerking of the eyeballs when they are rotated, and by a perceptible insecurity in their gait. They do not reel as drunken men do, just as blind men find their way about much better than we could do if our eyes were bandaged up; they have learned to get on fairly well with the help of experience and their other senses.

I am not sure whether in this account of the sense of rotation, of its organ, and of the use of it, I have carried all my hearers with me, and convinced you of the real existence and real practical use of this sense. I hope, however, I have made it clear that the subject is worthy of attention, and that we have here matter for the careful consideration of physicists, physiologists, and psychologists.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Oxford.—In a Convocation, held on Tuesday last, the University, or at least a section of it, displayed itself in an unfavourable light. The Convocation House was crowded, not because of the Statute on Research Degrees, which came before the House, and passed its final stage without opposition, but because of the proposal, which seemed to be a modest one, that Anthropology should be included among the subjects of the Final School of Natural Science, not as an extra, but as an equivalent subject. This proposal was from the first strongly opposed by a few members of Congregation, but passed the two readings in that body by substantial majorities. The opponents of the subject, however, were not content to accept the results of these votes, and issued an urgent whip to members of Convocation, with the result that the statute was rejected by 68 votes against 60. Presumably the philosophers, historians, and divines who succeeded in throwing out the statute at its final stage are pleased with their performance. To the outside world, which is less than ever convinced that education is comprised within the limits of the subjects of the School of Literæ Humaniores, their action will be but another instance of the incompetency of a section of the classical world to understand what is going on around them. The circular which was issued

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by the opponents of the statute was so artfully worded as to rouse theological suspicions. Reference was made to the undesirability of the comparative study of religions, and it was obvious that a considerable proportion of those who attended to vote against the measure, had come in obedience to a summons to resist the enemy, and were in no way qualified to form a judgment on educational matters. The larger proportion, however, consisted of those classical teachers whose belief it is that science may safely be ignored in a nineteenth century education and that a "good general education" means only a training in the Greek and Latin languages, with a smattering of ancient history and philosophy. The result of the vote was a great disappointment to those who had hoped that the work of Prof. Tylor, Prof. Arthur Thomson, and Mr. H. Balfour, would find its fruition in a small but earnest school of anthropologists in Oxford.

THE National Association for the Promotion of Technical and Secondary Education has made arrangements for a Conference of the representatives of Technical Education Committees to be held at the Royal United Service Institution, on July 11, when the Duke of Devonshire, President of the Association, will take the chair. The object of this Conference is to discuss means whereby the various authorities charged with the provision of technical education may be brought into closer relationship, and may be enabled to avail themselves of the results of the experience of others as regards many important details of their work. Among the subjects which it is proposed to deal with are (*a*) scholarships (local conditions and uniformity in respect to award and tenure), (*b*) evening continuation schools (the co-ordination of their work with that of evening science, art, and technical classes), (*c*) trade and technology classes and their relation to the various trades.

THE chemical and engineering societies formed by the members of many of our polytechnic institutes might emulate, with advantage, the Engineering Society of the School of Practical Science, Toronto. We have lately received a volume of 253 pages containing the papers read before the Society during the session 1894-95. The papers refer to both the theoretical and practical sides of engineering, and their publication cannot but encourage investigation among the students. A plan adopted by this Society, and by a number of American societies of a similar kind, is worth noting. Before a paper is read, 150 proofs of it are distributed among engineers and specialists interested in the subject with which it deals, and their opinions upon any particular point are invited. The replies received are read after the paper, and help to make the discussion more general and of greater value than it otherwise would be.

THE Corporation of the Massachusetts Institute of Technology, Boston, have a good understanding of what technical education means. The following paragraph, from the *Calendar* of the Institute received a few days ago, should be borne in mind by the organisers of technical education in this country:—"The foundation of all sound technological education requires not only thorough theoretical training, but also prolonged, well-directed laboratory drill which shall first give the student the power of close and accurate observation, and then bring him into direct contact with the material problems of his future profession." It is by acting upon this educational principle that the Massachusetts Institute has gained such a large measure of success.

TABLES showing the number and proportion of pupils attending secondary schools in London are given in the *Technical Education Gazette*. The returns obtained show that the number of pupils receiving education in 84 public endowed and public proprietary schools is 19,072, and the number receiving education ni 126 private or semi-private schools is 7107. The proportion which pupils attending secondary schools bear to those attending public elementary schools, may be gathered from the fact that the number per 100,000 of the population attending secondary schools is 623, while the number per 100,000 of the population attending public elementary schools is 16,904.

SCIENTIFIC SERIALS.

Bulletin of the American Mathematical Society, vol. i. No. 8 (May 1895).—Kinetic stability of central orbits, by Prof. Woolsey Johnson, contains an investigation, of an elementary character, of a problem not discussed in the fourth edition (p. 125) of Tait and Steel's "Dynamics of a Particle." It is a satisfactory discussion of the problem so far as it relates to central orbits. The note was read before the Society at its April meeting.—Dr. J. Pierpont, in a short paper, read before the Yale Mathematical Club, entitled "Lagrange's place in the Theory of Substitution," though he cannot vindicate Lagrange's right to the title of creator of the theory of substitutions, presents a few examples of his methods in order to show the importance of considering him from this point of view. "Lagrange was led to the study of this theory by his attempts to solve equations of degree higher than the fourth."—Gauss's third proof of the fundamental theorem of algebra, by Prof. Bôcher, indicates the connection between Gauss's third proof that every algebraic equation has a root and those branches of mathematics which have since been developed under the names of the theory of functions and the theory of the potential. The notes, among other details, give the different courses of lectures in mathematics at American and European colleges.—There is the usual long list of new publications.

Wiedemann's Annalen der Physik und Chemie, No. 5.—Wave-lengths of ultra-violet aluminium lines, by C. Runge. The lines of the spark spectrum near 186 μ wave-length are of great intensity, and may be used as standards of reference. They were therefore carefully determined by means of a Rowland concave grating and sensitive plates prepared by Schumann's method. They were compared with the spectrum of iron, and referred to Rowland's standard wave-lengths for that substance. The figures for the four lines at 760 mm. pressure and 20° C. were 1854·09, 1862·20, 1935·29, and 1989·90. The wave-lengths reduced to a vacuum would be about 0·6 units greater.—On the dichroism of calcspar, quartz, and tourmaline for infra-red rays, by Ernest Merritt. The absorption of the infra-red rays in these substances depends upon the plane of polarisation. Especially in calcspar and in tourmaline the two curves representing the transmittency for the ordinary and the extraordinary ray, respectively, are quite different, so that they appear to be independent of each other. The following absorption bands were observed in these curves: Calcspar, at 2·44 μ and 2·74 μ for the ordinary ray. These are very sharp. Some broad bands also appear at 3·4 μ, 4 μ, and 4·6 μ. The extraordinary ray is absorbed at wave-lengths of 3·28, 3·75, and 4·66 μ. Quartz shows an absorption band for the ordinary ray at 2·9 μ. When the wave-length exceeds 4·75 μ the substance is practically opaque for both rays. Tourmaline absorbs the ordinary ray of wave-length 2·82 μ. The two curves intersect at 2·30 μ and again at 3·84 μ, so that between these two points the dichroism of tourmaline is reversed.—On the transmittency of solid bodies for the luminiferous ether, by L. Zehnder (see p. 153).—On the measurement of high temperatures with the thermo-element and the melting-points of some inorganic salts, by John McCrae. The melting-points of a number of salts, chiefly alkaline haloids, were determined by means of a platinum and platinum-rhodium couple, whose E.M.F. is proportional to the temperature between 300° and 1400°. The temperature of the alcohol flame, as shown by the same couple, was 1488°, and that of the Bunsen flame at its hottest part, 1725° C.—On electric resonance, by V. Bjerknes. This is an important contribution to the theory of Hertzian oscillations. The author considers the effect of the periods of the oscillator and the resonator, and their logarithmic decrements, together with a constant measuring the intensity of the oscillations. He thus arrives at several fundamental laws, such as: The secondary spark potential is proportional to the square of the period of the resonator, the magnetic or thermal integral effect to its cube, and the electric integral effect to its fifth power.

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, June 14.—Captain W. de W. Abney, President, in the chair.—Mr. Burstall continued the reading of his paper on the measurement of a syclically varying temperature. Three sizes of platinum wire have been employed for the thermometers in order that some idea might be formed as to the magnitude of the error caused by the lag of the temperature of the wire behind that of the gases. The constants of the platinum thermometers were determined either by comparison with a standard Callendar platinum thermometer or by means of

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